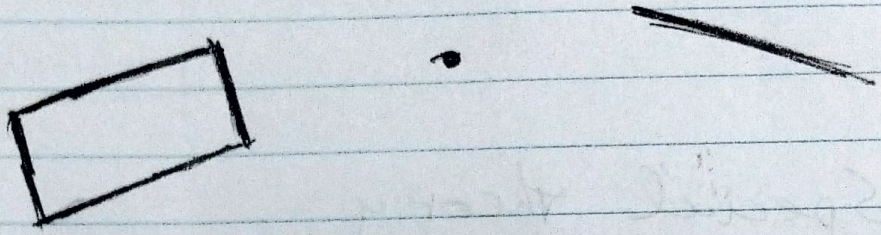
Special theory of Relativity

Physical Meaning of Geometrical Propositions



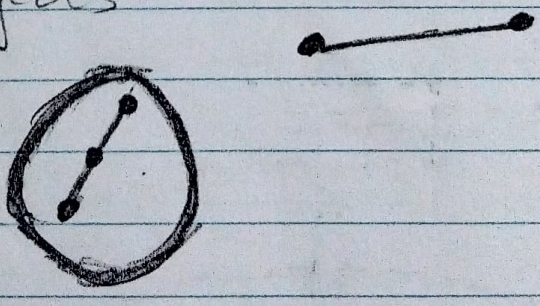
→ axioms
→ Proofs

"TRUTH" → unanswerable if without meaning

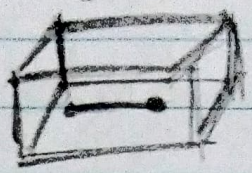
Euclidean geometry → Related ideas of straight lines

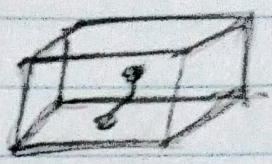
Geometry → logical connection of ideas
↳ no concern from objects of experience

Geometrical objects correspond to more or less real objects.



Euclidean -> single proposition





↳ proposition of or possible relative position of practically rigid bodies

‖ Geometry

BRANCH OF PHYSICS

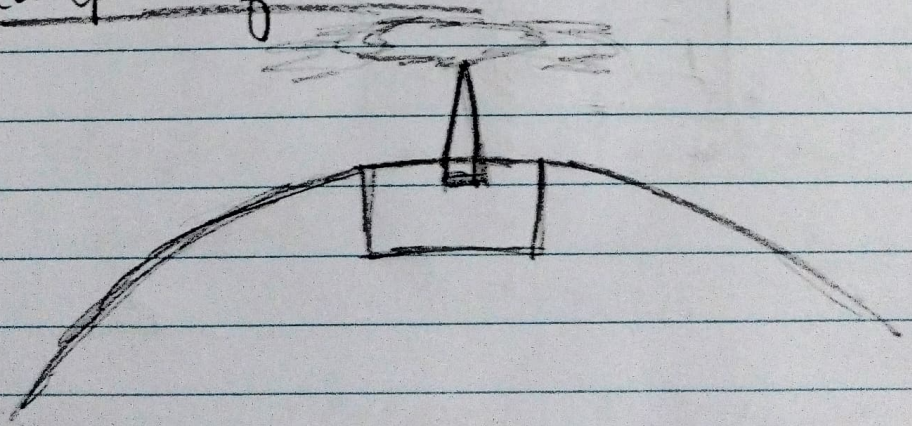
↳ truth can be evaluated (for now consider it even with experience)

2

System of Co-ordinates

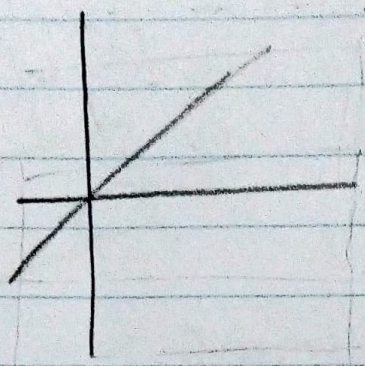
Every description of position of object in space

Conception of Position:



Numerical measures → Replace names

↳ Cartesian coordinates



Specification of position

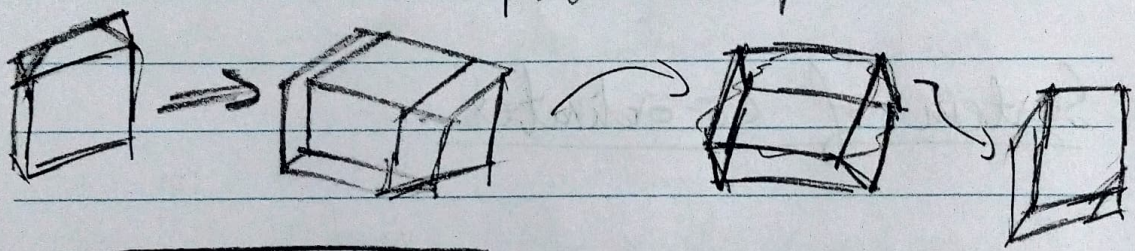
↓

Coordinates

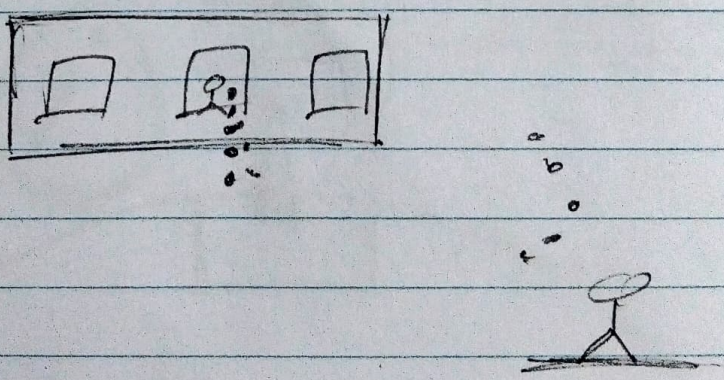
3

Space & Time in Classical Mechanics

Mechanics → how bodies change position in space with time



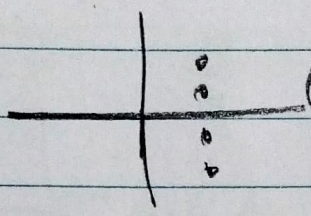
Position & Space



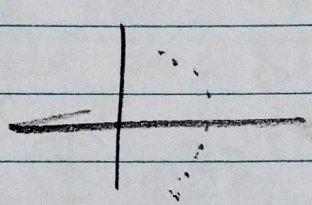
Space → Motion relative do a practically rigid body of reference.

coordinates

stone



&



Trajectory ⇒ only relative to a particulare reference body.

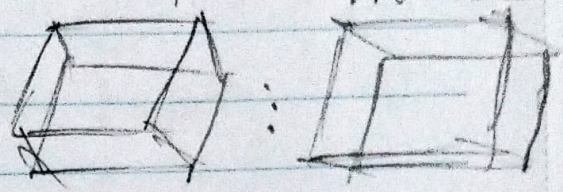
Independently existing trajectory X

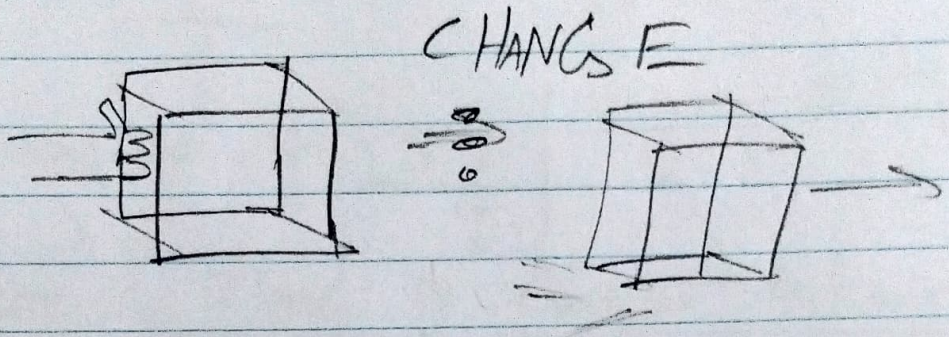
for every point of trajectory ⇒ there exists a time related do it

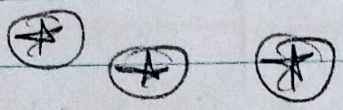
Measured value

Galilean System of Coordinates

Law of inertia →







→ law of inertial hold for them do higher degree

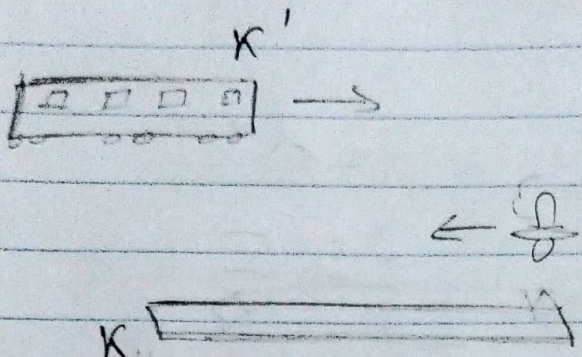
EARTH

→ Law of inertia does not hold if coord. sys attached to earth.

* A system of coordinates to which the state of motion is such that the law of inertia holds relative do it is called the -

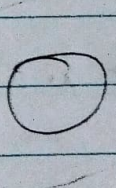
Galilean System of coordinates

The Principle of Relativity (in Restricted Sense)



Principal of Relativity:
(In restricted sense)
if rel. to K, K' is uniformly moving, (not rotating) then natural phenomenon along K' is same as according to K ie the same laws wrt K, in K'
(hold perfectly) in
→ very good for Mechanics pov.

But in optics & electrodynamics?

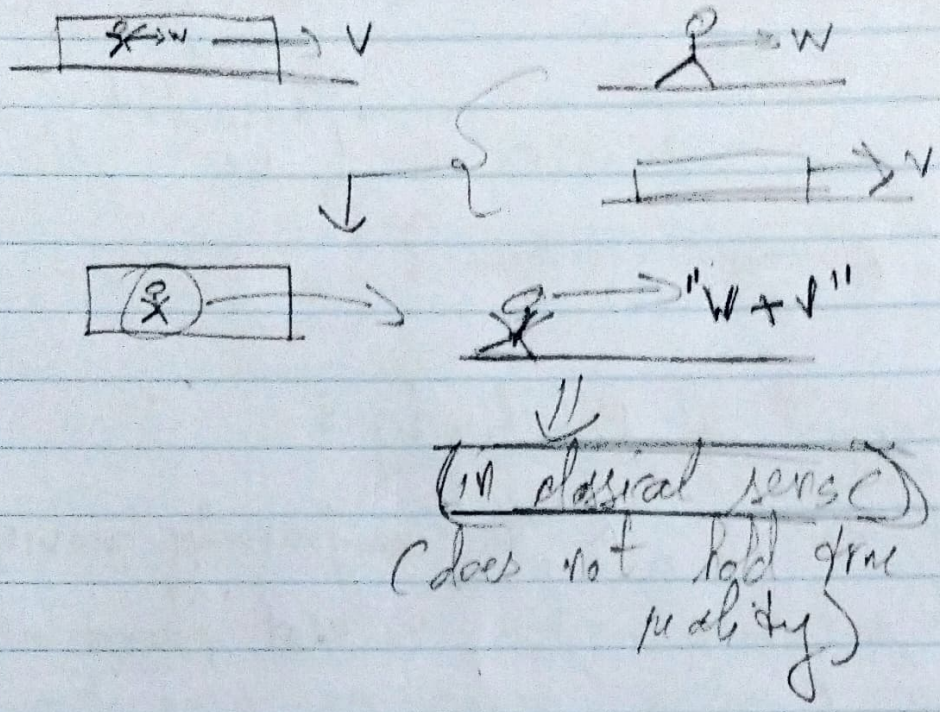


→ obs. never revelead physical non equivalence of different directions

very powerful argument in favor of Principle of Relativity

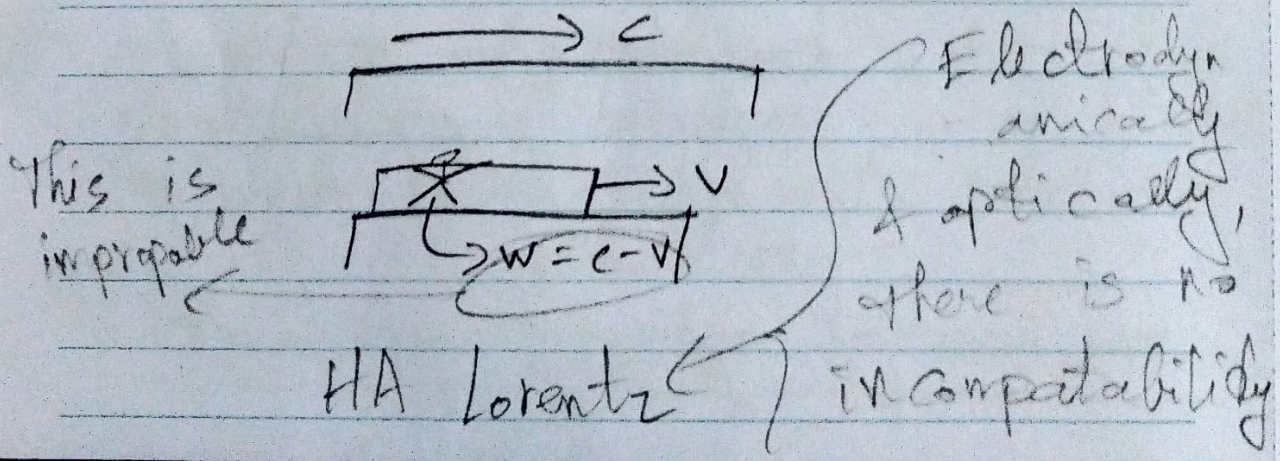
6

Theorem of the Addition of Velocities employed in Classical Mechanics



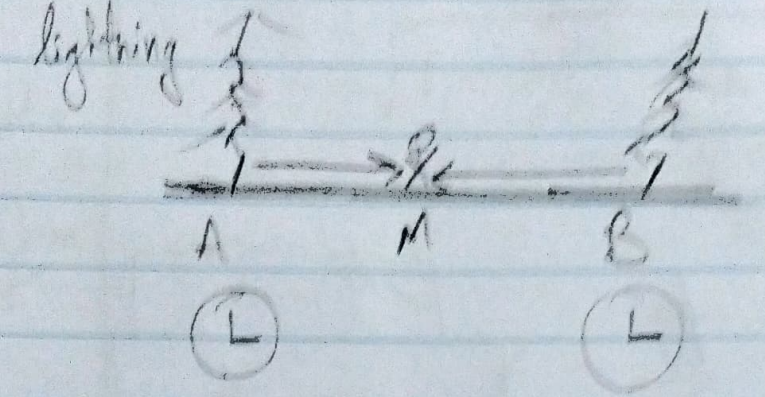
7

The Apparent Incompatibility of the Law of Propagation of Light with the Principle of Relativity



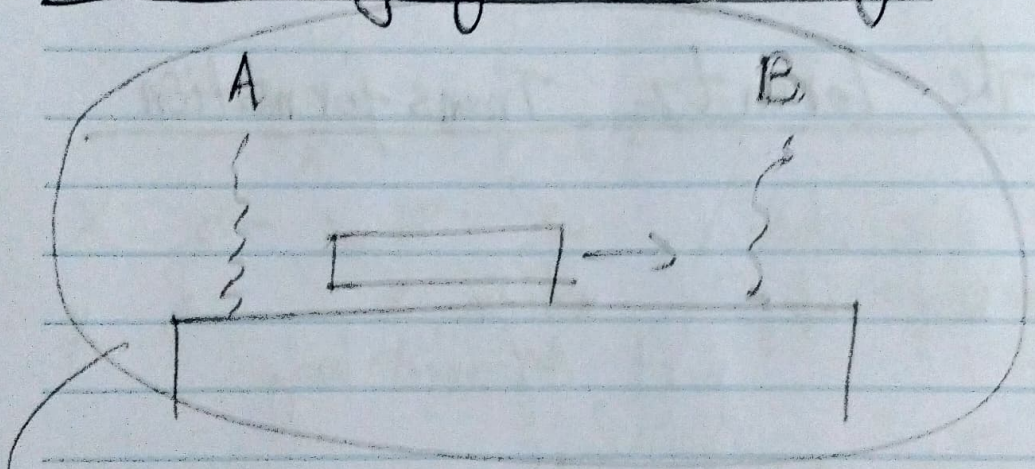
8

On the Idea of Time in Physics



9

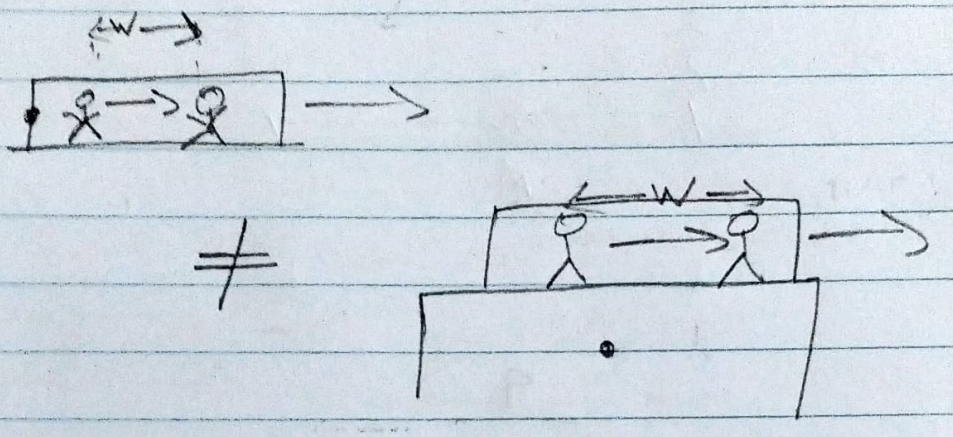
The Relativity of Simultaneity



This situation reveals at the absoluteness of "time".

10

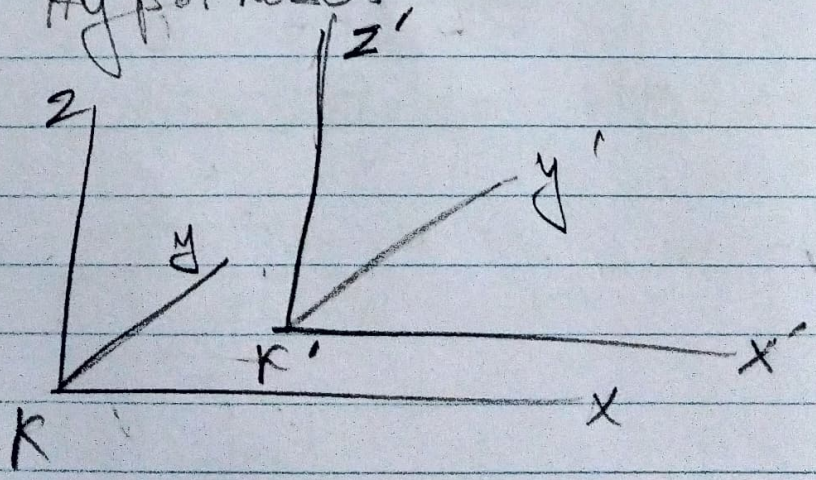
On the Relativity of the Conception of Distance



11

The Lorentz Transformation

Absoluteness of Time → X
Dist indep of Motion wrt reference body → X
→ two unjustifiable Hypotheses



for motion in 1D only,

Lorentz Transformation

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$y' = y \qquad z' = z$$

$$t' = \frac{t - \frac{v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\left.\begin{aligned} x' &= x - vt \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned}\right\} \text{Galilean transformation}$$

AND if $x = ct$

$$x' = \frac{(c - v)t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$x' = ct' \Leftarrow$

$$t' = \frac{\left(1 - \frac{v}{c}\right)t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

The Behaviour of Measuring-Rods & Clocks in Motion

$$x_{(beg.)} = 0\sqrt{1 - \frac{v^2}{c^2}}$$

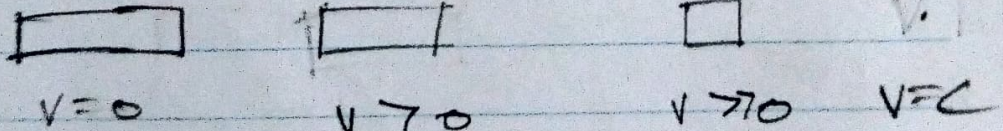
$$x_{(end)} = 1\sqrt{1 - \frac{v^2}{c^2}}$$

$$\text{dist b/w them} = \sqrt{1 - \frac{v^2}{c^2}}$$

length of metre rod moving with 'v' in ~~K~~ 'K' as seen from 'K'.

$$= \sqrt{1 - \frac{v^2}{c^2}} \text{ of a metre.}$$

(A) Rigid Body is shorter when in motion.



Due to $\Rightarrow \left(\sqrt{1 - \frac{v^2}{c^2}}\right)$

Second clock at $x' = 0$ of k'
$\Rightarrow t' = 0$ & $t' = T$ are two successive
ticks of this clock

$$t' = \frac{T}{\sqrt{1 - \frac{v^2}{c^2}}}$$

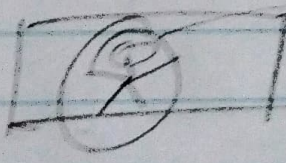
↳ somewhat larger than T

↓

clock goes more slowly than
when at rest.

13

Theorem of Addition of Velocities. The Experiment of Fizeau



$\rightarrow k' \Rightarrow x' = wt'$

↓ using Galilei transformation

$x = (v+w)t$

↓

w

using $x' = wt'$ also,

$$w = \frac{v+w}{1+\frac{vw}{c^2}}$$

HO

14

The Heuristic Value of Theory of Relativity

x, y, z, t & x', y', z', t'

exists everywhere
(i.e in every land of nature)

15

General Results of the Theory

The KE of a particle becomes

$$\frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}$$ instead of $m\frac{v^2}{2}$

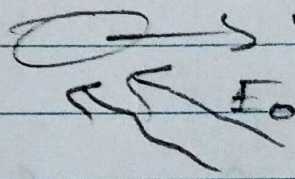
> in series form it is,

$$mc^2 + m\frac{v^2}{2} + \frac{3}{8} m\frac{v^4}{c^2}$$

Mass & Energy are not different.

Law of cons of energy should hold wrt to K & also wrt to every K' (Galilean) lorentz transformation is the leading factor

Body moving with 'v', absorbs E_0 in form of radiation



↳ energy inc by :: $\frac{E_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$$KE = \frac{\left(m + \frac{E_0}{c^2}\right)c^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

↳ same energy as a body of mass $= m + \frac{E_0}{c^2}$

→ if body store E_0, then its inertial mass inc by $\frac{E_0}{c^2}$

Inertial mass → measure of energy

$$E = \frac{mc^2 + E_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

16

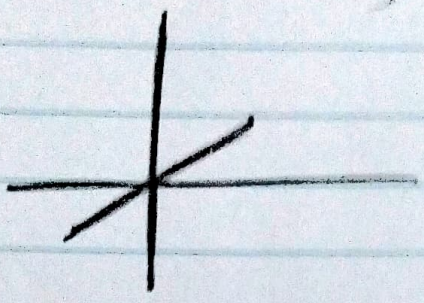
Experience & the Special theory of Relativity

A contraction in dir^n of motion is observed when

contracted length $\propto \sqrt{1 - \frac{v^2}{c^2}}$

17

Min Kowski's Four-dimensional Space



4D Time space continuum.

Challenges the absoluteness of Time.

$$t' = \frac{-/- \frac{V}{c^2} x}{\sqrt{\exists \cdot \frac{V^2}{c^2}}}$$